Earth & Environmental Sciences Division

News, Views & EEScience

Safety

A Message from Jeff

Jeff Hansen, Division ES&H Officer, 667-5043, jchansen@lanl.gov

Unlisted Electrical Safety Issues

Effective on October 1, 2003, all Los Alamos personnel or contractors are requested to use or purchase electrical devices that are "listed" and carry a mark from a Nationally Recognized Testing Laboratory (NRTL) or have been tagged by a Los Alamos Electrical Safety Officer. If you have equipment now in your possession that is not carrying a UL® label or a certification from an EES Electrical Safety Officer, please do not use it until we can look it over.

You may have noticed several recent articles in the Los Alamos News Bulletin Readers' Forum about the labeling of electrical equipment for safety. There are several labels that are acceptable within the electrical safety LIR, not limited to UL®, although this one is seen the most often.

The EES Division's group and division electrical safety officers have recently completed an inspection and tagging program of the division looking for NRTL listed equipment. We located approximately 3,000 pieces of electrical equipment.

While we found that most of our equipment is properly listed, typically with a UL® label, we did find a few that had no certification. Some of this equipment apparently was brought here from home.

At least for now, a division's certification is not automatically acceptable to another division. Those who find themselves at the Test Site will find that DX does not automatically accept EES Division certifications. This will probably be true for RRES, HSR, and any other divisions we may work with.

Some scientific equipment is not NRTL tested or listed, yet we still require it to do our job. In this case, a group or division Electrical Safety Officer will have to inspect it for approval. If it is found to be unacceptable, it cannot be used here. This is particularly true for local Laboratory built or modified equipment. Contact Jeff Hansen, 7-5043 or Gary Luedemann, 7-7674 for details if you need a certification.

Security

An Ear on the LIR from Tony

Tony Montoya, Acting Division Security Officer (DSO), 7-8065, antonio@lanl.gov

Reminder on Point to Point

Several months ago we requested that point-to-point software not be used. Effective immediately, we are asking people not to use "GoToMyPC" software. This software makes your PC vulnerable. Immediate action to block access from our network is being taken.

- A Rock Solid Message from Terry Wallace

NEW EES-2 Group Leader

Dr. James Bossert is the new Group Leader in EES-2 (Atmospheric, Climate and Environmental Dynamics). Jim has been at Los Alamos since 1990, and has served in various leadership roles including Deputy Group Leader in EES-2, a project coordinator in D Division, and Congressional Liaison for Associate Director for Threat Reduction. Jim has served as a lead in program development in the EES Division for issues associated with Homeland Security, and is presently helping lead the efforts in complex systems and climate sciences with the Energy and Environment Council.

Jim received his B.S. in Atmospheric Sciences in 1982, and a Ph.D. in Atmospheric Sciences from Colorado State University in 1990. Jim's research expertise is in coupled meteorological systems, and he has worked on problems such as climate simulations for the western US, the dispersal of pollutants over urban settings, and physics based simulations of wild fires. Research on the last topic earned Jim a R&D 100 Award as part of the FIRETEC team.

Jim's outstanding experience in research and all aspects of management will be a very valuable resource for the leadership of EES-2. Please join me in welcoming Jim to his new job.

Mike Ebinger will continue as the Acting Deputy Group Leader of EES-2 until a Deputy Group Leader is appointed.

EES-7 Group Leader Arrives

Kenneth (Ken) Rehfeldt arrived on October 20 as the new EES-7 Group Leader.

Marc Witkowski was appointed by Frank Perry, Group Leader, as the Acting Deputy Group Leader of EES-9 for the next 90 days.

Debra Saiz - New IGPP Administration Operations Specialist

Gary Geernaert, IGPP Director, announced that Debra Saiz joined IGPP on November 11. She has a wide range of administrative and office experience, acquired recently from working in NMT Division and Highlands University.

Dollar$ and $ense New$

We are in the process of submitting proposals for General Purpose Equipment and LDRD-DRs! I will have more on the fiscal issues in my November update.

Service Anniversaries & Congratulations to the Following

Christopher Bradley, **EES-11, 5 years**

Laurie Triplett, **EES-2, 5 years**

News from the Science and Engineering Leadership Team

Chris Bradley, Chair,
5-6713, cbradley@lanl.gov

The SELT's October meetings have been to prepare for the upcoming review of

LDRD-DR from EES Division. Like last year, we will soon be calling for a pre-proposal from the division PIs to help them with the proposal process. The call for new pre-proposals will most likely be in the first week of November. This process will involve the Division Office and former SELT members to help the PIs with the DR process.

On October 6th, the SELT hosted our past Division Leader, Paul Weber, now with the Associate Director's office of Threat Reduction (ADTR) to discuss his role in that office. Paul spoke to us on Defense Transformation and the new military. Paul is the Deputy Director of Science and Technology in ADTR where a significant part of his job is to interface with DoD programs and identify ways in which LANL/TR can aid the new military. The discussion was very enlightening and he pointed out where EES can help in GIS, remote sensing, and intelligence projects. The SELT would like to have a follow up meeting with Paul.

The SELT membership has changed. Paul Rich, our most senior member, has elected to rotate off the SELT in November. As a result, Jeff Heikoop will be the new Vice-Chair and will rotate into the chairmanship in November. A unanimous vote elected Jeff to be the new Vice Chair.

Upcoming SELT Sponsored Events:

- *October 27 –* Terry Wallace *will discuss the Division Business Plan with SELT.*
- *November 10 (tentative)* Dave Janecky *has agreed to talk about BES with SELT – this will be announced to the Division.*
- *November –* Gary Geernaert *has been invited to discuss funding structure and the E&E Council and how EES might become more closely aligned with their mission.*

Weekly Highlights / Accomplishments sent to ADSR

Publication Released on Seismic Recordings of the Carlsbad, New Mexico Pipeline Explosion

The August 2003 Bulletin of the Seismological Society of America published the results of the August 19, 2000, (BSSA, Vol. 93, p. 1427-1432) buried natural gas pipeline rupture and explosion that occurred in southeastern New Mexico. Authors are Keith D. Koper, Terry C. Wallace, and Richard C. Aster. Koper is from the Department of Earth and Atmospheric Sciences, Saint Louis University, Wallace is from the Earth and Environmental Sciences Division at Los Alamos National Laboratory (formerly of Department of Geosciences, University of Arizona), and Aster is from the Earth and Environmental Science Department at New Mexico Institute of Mining and Technology.

The study concludes that, **"The seismic recordings of the natural gas pipeline accident in southeastern New Mexico provide source constraints that are unavailable from traditional investigative techniques."** The study further states, "Such a large time between the two events implies that the source of the ignition was not sparking or heat produced by the pipeline rupture but more likely a heat source at the victim's campsite 100-200m away. This 24-sec time span also bears on the amount of punitive damages the pipeline operator is responsible for, since the victims were in a state of extreme distress during this time period. In many forensic seismology studies the seismic analysis give results that are important, but mainly in a corroborative sense. In contrast, in the case presented here the seismic constraints are unique with respect to all other sources of data and means of investigation."

Earth & Environmental Sciences Division

Dr. Terry C. Wallace, Jr. is currently the Acting Division Leader of the Earth and Environmental Sciences Division at Los Alamos. He is a well-recognized and distinguished seismologist with broad knowledge in geosciences. He has authored or co-authored more than 80 peer-reviewed publications in many areas of seismology and tectonics, including ground-based nuclear explosion monitoring, plate tectonics, regional structure, and forensic seismology. He has a Ph.D. in Geophysics from the California Institute of Technology.

Los Alamos Names New Water Portfolio Manager

The Energy and Environmental Council of Los Alamos National Laboratory named Dr. Cathy Wilson as the new water portfolio manager. Wilson is a staff member in the Earth and Environmental Sciences Division. The long-term objective of the water portfolio is to position Los Alamos National Laboratory as a national and international leader in solving water problems. Dr. Everett Springer, who was the original water portfolio manager, recently stepped down to accept a partial position in Science and Technology Based programs to work on the Los Alamos-University of California relations. Springer did an outstanding job in shaping and guiding Los Alamos' water programs and has helped to build partnerships with industry and explore the relationship between water use and energy production.

One of Dr. Wilson's first projects will be to conduct a new road mapping exercise for water. **Development of the water road map is complex because there are many disparate water activities at the Laboratory and the scope of "water issues" is large.** However, she has confidence that we can identify problems that fit both the Los Alamos National Laboratory mission and the unique skills of the Laboratory personnel.

Yucca Mountain Tours the Army's 3rd Battalion, 61st Air Defense, Department of Justice, National Regulatory Commission, and Others

Bruce Reinert of the Earth and Environmental Sciences Division toured a group of 40 individuals from the Army's 3rd Battalion, 61st Air Defense on September 15. Tours were conducted on September 16 for attorneys from the Department of Justice that included: Ron Spritzer, John Bryson, and George Hellstrom, DOE Counsel.

A group of 25 from the Bechtel Women of Southern Nevada Group toured on September 17 and Richard Kovach toured individuals from the National Regulatory Commission on September 19 that included: Jon Peckenpaugh, Systems Performance Analyst, Alavanja Ridge, Nuclear Safety Intern, James Danna, Senior Systems Performance Analyst, Omid Tabarabai-Yazdi, Project Manager, Veronica Klein, Nuclear Safety Intern, Melanie Wong, Project Manager, and Paul Lohaus, Director, Office of State and Tribal Programs, Scott Flanders, Section Chief, Environmental & Low-Level Waste, Adrienne Lester, Environmental Scientist, Lawrence Kokajko, Branch Chief, Robert Kuntz, General Engineer, Jason Fleming, Nuclear Safety Intern.

Representatives from the US Army Corps of Engineers and Colorado School of Mines toured various locations in the underground to observe excavation techniques involving drill and blast verses a mechanical miner on September 23. Representatives from the Corps included: Stephen Brent Tatro, William James Harrison, James Paul Fast, John Ray Hess, and Teresa Ann Witt; Levent Ozdemir, and Tibor George Rozgonyi, Colorado School of Mines, also were present on the tour.

Los Alamos Geophysicists Present Novel Wave-Equation Migration Methods

Lianjie Huang, Hongchuan Sun, and Michael Fehler of the Earth and Environmental Sciences Division's Geophysics Group were in Houston on September 17-18 to discuss their recent work in seismic migration imaging. On September 17 they met with representatives of Core Labs and Sensorwise to discuss issues related to cross well imaging. They discussed work they have recently completed on a challenging dataset provided to Los Alamos by these two companies. This effort is an initial attempt to make a revolutionary change in our ability to image subsurface formations using crosswell data. On September 18, they ran an all-day meeting, hosted by Fairfield Industries, in which Los Alamos researchers made about six hours of presentations describing their work on wave equation migration imaging using surface seismic data. A total of 40 people representing 18 companies were present at the meeting. Topics presented included: (1) a new imaging condition that yields a normal reflection image, which can be more reliably interpreted to determine rock properties at an interface within the Earth; (2) offset-domain migration in which all shot gathers can be migrated simultaneously in a manner that is intended to be computationally faster than conventional shot-domain migration; (3) a novel approach for doing 3D migration that we call stationary-phase migration that provides better images than other approaches for offset-domain migration while maintaining the speed advantage of other methods; (4) developments in controlled aperture wave equation migration, which is a method for obtaining improved images in shot-record migration by limiting the portion of the subsurface for which each shot migrates; and finally (5) some work that Los Alamos researchers have been doing to image a large 3D Gulf of Mexico dataset using shot-domain migration. **The visit produced excellent interactive discussions about Los Alamos' work and capabilities. The industrial participants indicated that Los Alamos' images are superior to those obtained using their own wave-equation migration methods.**

Los Alamos Completes Nation's First Microhole for Stripper Oil Production

A team in the Geophysics Group in the Earth and Environmental Sciences Division, consisting of James Thomson, David Anderson, Donald Dreesen, and Jim Albright, **completed the design and construction of the nation's first microhole for stripper oil production.** The microhole, having a total depth of 497 ft. and hole and cased diameters of 2-5/8 in. and 2-1/8 in. respectively, was drilled and cased at DOE Rocky Mountain Oilfield Test Center (RMOTC) at Teapot Dome, Wyoming in September. RMOTC assisted Los Alamos by obtaining the necessary state drilling permit, preparing the site, and running casing. RMOTC personnel will perforate and hydraulically fracture the microhole prior to putting it on production late in November.

Microhole technology is exclusively a Los Alamos development. The Los Alamos microhole drilling system is the culmination of theory, benchtop - and field - testing, modification, and integration of commercially available components. Drilling is accomplished through hydraulically driven, coiled-tubing-

deployed, positive-displacement motors and rotary drill bits. Microholes serve the same purpose as wells drilled conventionally for infield or stripper production but does so at a greatly reduced cost.

The demonstration at Teapot Dome demonstrates the ability to drill and complete microholes and significantly increases the economically recoverable reserves in the nation's depleted oil fields.

Los Alamos Hosts Valles Caldera Workshop on Paleoclimate Change and Scientific Drilling

The Institute for Geophysics and Planetary Physics in the Earth and Environmental Sciences Division is sponsoring an interagency and interdisciplinary workshop that will focus on the possibilities of conducting scientific drilling, paleoenvironmental reconstruction/paleoclimate modeling, and other research on the well-preserved lacustrine deposits in the Valles Caldera, New Mexico. On October 22, a series of short talks on various topics will be held at the Fuller Lodge in Los Alamos, NM and a half-day field trip to the caldera on October 23 will examine some of the deposits. The remainder of the day on the 23rd will focus on discussing preliminary science needs, a modest drilling program, and funding options.Contacts: Fraser Goff, Giday Wolde-Gabriel, Jeff Heikoop, or Julianna Fessenden-Rahn, EES-6.

"Intergalactic Magnetic Fields" by Los Alamos' Kronberg Selected by Japanese for Parity

Philipp P. Kronberg, an astrophysicist and Orson Anderson Scholar at Los Alamos National Laboratory's Institute of Geophysics and Planetary Physics in the Earth and Environmental Sciences Division was notified that Maruzen Co. published his publication, "Intergalactic Magnetic Fields," in the Japanese magazine called Parity. The original publication in the December 2002 *Physics Today* was translated into Japanese and included by the Japanese editors in Parity. Kronberg's work on magnetic fields "spreads far beyond the galaxies that created them and they represent a significant, and only recently revealed, component of the cosmic energy budget." Kronberg discusses topics such as Detecting astrophysical magnetic fields, Telltale synchrotron radiation, Background probes, Beyond clusters (Coma Clusters), Too strong too early, Intergalactic fields from stars, Supermassive black holes, Generators and accelerators, and Captured energy and cosmic history. In the publication, Kronberg states, "Unlike electromagnetic radiation from astrophysical sources, distant static magnetic fields are inherently difficult to detect. Nonetheless, recent measurements have begun to reveal that such fields exist at significant strengths, and on surprisingly large scales in the extragalactic universe. **These discoveries present us with an important, previously unrecognized component of energy and force in the cosmos."**

Yucca Mountain Tours Schools, Nuclear Regulatory Commission, and EPA

Bruce Reinert of the Earth and Environmental Sciences Division at Yucca Mountain toured a group of 40 individuals on September 29 and 30 from Saint Christopher Middle School and Shadow Ridge High School. Also attending the tours were Anthony Baratta, Atomic Safety and Licensing Board, from the Nuclear Regulatory Commission and two representatives from the Environmental Protection Agency.

Nanos: Yucca Mountain Important in Establishing Good Track Record

The Yucca Mountain Program (YMP) New (fiscal) Year's All Hands Meeting was held at Fuller Lodge, Los Alamos, New Mexico on October 2. The Laboratory Director's Office hosted a reception after the meeting and it culminated in a visit and personal message

delivered by Director G. Peter Nanos. Director Nanos congratulated the group and noted that **the public has a very strong fear of anything nuclear and that it will require considerable education to convince them that nuclear facilities are safe. In that respect, the work done at Yucca Mountain is the beginning of this confidence-building process.** In the long run, the public must be convinced that nuclear energy is a clean and safe alternative to fossil fuel, and that nuclear energy is environmentally green. Director Nanos foresees that this process will take a long time but that it will eventually be the direction in which our nation goes. Successes at YMP are important in establishing a good track record for nuclear energy by solving the problem of the disposal of nuclear waste.

The purpose of the meeting was to cap off the FY03 year by looking both backward and forward. In looking backward, the group assessed what went well and celebrated their triumphs as well as identified areas where improvements are needed. Dr. Ardyth Simmons, Program Manager for Repository Science, in the Earth and Environmental Sciences Division (EES), coordinated the meeting agenda and activities. She provided a vision for what lays ahead in FY04, including accountability models (new contract, more oversight, etc.), the working environment, what projects the team will focus on and the schedule of milestones.

The Acting Deputy Division Leader of EES, Dr. Craig Pearson, provided the introduction to the meeting. He noted that the Los Alamos YMP was highly successful in FY03, even in the face of unprecedented schedule demands, accelerated activities to support the Analysis Model Reports, Key Technical Basis Report, and the Technical Basis Report completion, as well as short responses to critical issues such as the License Support Network tasking. Many of the Los Alamos employees went to extraordinary and even heroic efforts to meet deadlines, overcome unexpected obstacles, and provide the high-level scientific products that will be necessary for a successful License Application in December 2004. The pace of the program is not expected to slow as we come into the final push to the License Application. He encouraged everyone to realize what an impact they have had on the Project and admonished those present to continue to supply the very best scientific input in FY04.

A major purpose of the meeting was to show appreciation for the hard work and successes of the past year. The Los Alamos participants on the YMP were presented certificates of appreciation from the Repository Sciences Program Office and a Director's-hosted reception followed the meeting.

DOE Fossil Energy Features Los Alamos' Microdrilling

A recent DOE web site states, "The attraction of microhole drilling is the prospect of greatly reducing the cost of drilling shallow- and moderate-depth holes for exploration, field development, long-term subsurface monitoring, and to a limited degree, actual oil and gas production. If the costs of these activities can be reduced, oil and gas reservoirs that are uneconomic to produce today could become economically viable in the future.

In 2003, after earlier exploratory research principally conducted by the Los Alamos National Laboratory, the U.S. Department of Energy's Office of Fossil Energy began placing additional emphasis on microhole technology. The Energy Department envisions microholes with diameters as small as 1 to 2 inches, from 1/25th to 1/50th the cross-sectional area of conventional wells.

Microhole technology is exclusively a Los Alamos development and programmatically resides in the Earth and Environmental Sciences Division. The Los Alamos microhole drilling system is the culmination of theory,

benchtop and field-testing, modification, and integration of commercially available components. Drilling is accomplished through hydraulically driven, coiled-tubing-deployed, positive-displacement motors and rotary drill bits. Microholes serve the same purpose as wells drilled conventionally for infield or stripper production and do so at a greatly reduced cost.
http://www.fe.doe.gov/programs/oilgas/microhole/#top

Los Alamos Attends 215th Containment Evaluation Panel

On October 1st and 2nd, several members of the Geodynamics Team in the Earth and Environmental Sciences Division (Wendee Brunish, Tom Kunkle, Ward Hawkins, David Coblentz and Chris Bradley) attended the Nevada Test Site (NTS) test readiness tour of the tunnel complex at NTS and attended the 215th Containment Evaluation Panel (CEP) meeting. The tour of NTS was led by Dr. Byron Ristvet of the Defense Threat Reduction Agency (DTRA) and included a tour of the big hole drilling complex/facility originated at NTS for the underground testing of nuclear weapons and a tour of P-tunnel, a Defense Nuclear Agency (formerly DNA now DTRA), facility for nuclear weapons effects tests. On October 2nd, the CEP met to discuss its role in the National Test Readiness Program and the expected needs and capabilities should the nation return to nuclear testing. The United States Geological Survey presented the results of a newly designed big hole video logger and Tom Kunkle and Byron Ristvet (DTRA) presented an intelligence review of Foreign Testing to the CEP.

Dartevelle Receives Postdoctoral Appointment at Los Alamos

Sebastien (Seb) Dartevelle has agreed to start his postdoctoral appointment in the Geophysics Group of the Earth and Environmental Sciences Division beginning in January 2004. **Seb is a pioneer in numerical simulation of granular material flow**, and his web site (http://www.granular.org/granular_medium.html) has garnered numerous awards. Seb's main project with his mentor, Kenneth Wohletz, will be numerical models concerning the response of geological materials to large and rapid deformations. He will also continue pursuing his novel approach to modeling explosive volcanism.

Winner of the September Mystery Image:

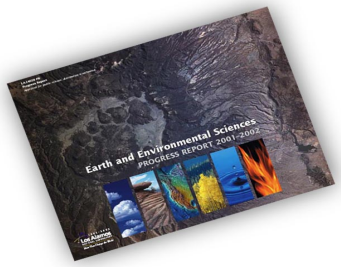
The location of this wetland is Sandia Canyon!

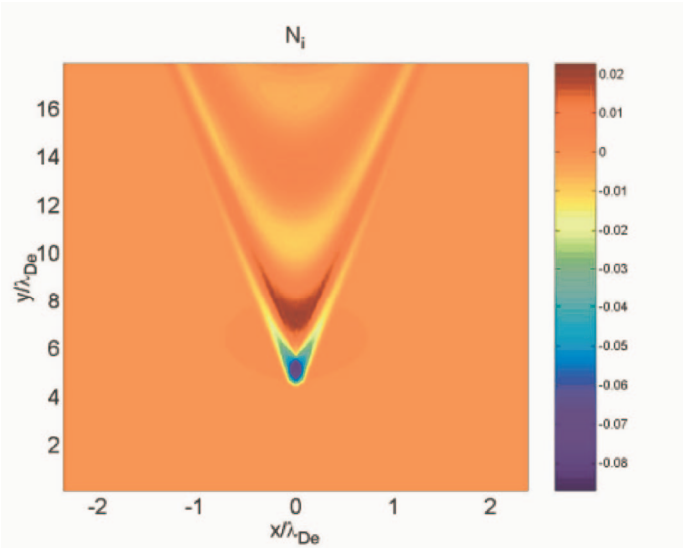
1st Place: Jeff Heikoop, EES-6
2nd Place: Debbie Pirkl, EES-DO

According to Jeff Heikoop, "Could it be the-Sandia Canyon Wetland…Let's see if all the people that I have taken down there get it right!"

The Sandia Canyon wetland receives treated sewage effluent from the Laboratory. Jeff states that, "We have been using light stable isotopes to identify ecologic processes relevant to issues of natural attenuation of contaminants as well as to carbon sequestration in terrestrial, aquatic, and oceanic environments. This research uses EES Division capabilities in geochemistry, ecology, and hydrology and supports Laboratory missions related to human health and environmental security."

"Tracing Ecologic Processes with Stable Isotopes," page 40 of the EES 2001 – 2002 Progress Report," Jeffrey Heikoop, Donald Hickmott, and Julianna Fessenden-Rahn, EES-6.
http://www.ees.lanl.gov/Resources/infra_collab.shtml





Dottie's Mystery Image for October:

- Is this an example of a trail left behind by a small object such as a meteor?
- Is this a high-speed encounter between a 2-solar-mass red giant and a 16-solar-mass black hole?
- Is this a probabilistic model of the fate of sediment and associated pollutants in fluvial systems?

Respond to: dot@lanl.gov

EEScience

Guest Editorial

The response of old *Pinus ponderosa* trees to stand density reductions: basic science and management implications

Nathan McDowell, EES-6
mcdowell@lanl.gov

Summary

Stand density reductions have been proposed as a method by which old-growth ponderosa pine (Pinus ponderosa) forests of North America can be converted back to pre-1900 conditions, thereby reducing the danger of catastrophic forest fires and insect attacks while increasing productivity of the remaining old-growth individuals. However, the duration of productivity response of individual trees and the physiological mechanisms underlying such a response remain speculative issues, particularly in old trees.

We used tree-ring measurements of carbon isotope ratios ($\delta^{13}C$) and basal area increment (BAI) to assess the response of intrinsic water-use efficiency (the ratio of photosynthesis, A to stomatal conductance, g) and growth of individual >250-year-old ponderosa pine trees to stand density reductions. We hypothesized that reductions in stand density would increase soil moisture availability, thus decreasing canopy A/g and increasing carbon isotope discrimination (Δ). After thinning, Δ increased by 0.89‰ (± 0.15‰). Trees in un-thinned stands showed no change in Δ (0.00‰ ± 0.04‰). The Δ response of thinned trees indicated that water-use efficiency decreased after thinning. Importantly, model estimates predicted that while water-use efficiency declined, its components increased: A increased by 15% after thinning and g increased by nearly 25%. These increases were primarily due to increased soil water availability, and resulted in significant and sustained growth increases. BAI doubled or tripled after disturbance, depending on the stand, and the increased BAI lasted up to 15 years after thinning. There was a strong relationship between BAI and modeled A, suggesting that changes in water availability and g have a significant effect on carbon assimilation and subsequent growth of these old trees. These results confirm that stand density reductions result in increased growth of individual trees via increased stomatal conductance. Furthermore, they show that a physiological response to stand density reductions can last for up to 15 years in old ponderosa pines if stand leaf area is not fully re-established. The implications for forest management are important both locally here in Los Alamos county, regionally, and globally. However, along with important answers, this study also generated intriguing questions regarding the time lag between canopy-assimilation of carbon and subsequent allocation of carbon to stemwood.

Background

Ponderosa pine is a conifer with a widespread range in North America, occurring from central Mexico to southern Canada, and is an economically important species on both public and private forests. Prior to 1900, frequent ground fires removed competing understory vegetation and maintained park-like stand structure in ponderosa pine forests. However, with the advent of fire exclusion circa 1900, stand density (the number of individuals per unit ground area) has increased dramatically. Fire exclusion has resulted in increased regeneration of understory plants as well as invasion of shade-tolerant conifers, resulting in increased competition and reduced productivity of overstory trees. Reductions in growth capacity of individual trees results in increased susceptibility to attack from insects such as the mountain pine beetle. Of particular relevance to the public is the increased danger of catastrophic forest fires associated with the large fuel loads in the dense forests. Concern is mounting that old-growth pine forests of western North America are in danger of disappearing due to fire and insect attack unless intervention via management techniques is employed.

Thinning of understory competition to reduce stand density is a popular new management method because it effectively reduces within-stand competition and reduces the danger of catastrophic wildfires while maintaining the presence, and potentially increasing the vigor of old-growth trees. However, there has been some speculation on whether or not old trees can respond to decreased competition, and if so, the duration of the growth response is also unknown.

Even beyond our lack of knowledge of growth responses of old trees to stand density reductions is our lack of understanding of the mechanisms of growth responses for trees of any age. In relatively dry ecosystems it seems likely

that soil moisture availability should increase after partial removal of transpiring leaf area via thinning, thereby increasing water availability to the remaining trees. However, there is only mixed evidence in support of this theory. Relevant to our local area here in the Southwest, a previous study of mature ponderosa pine trees in Arizona found no growth or physiological thinning response, although the thinning was very light and the sampling was of very low intensity.

If thinning does result in increased soil water availability then crown-scale stomatal conductance (g) should increase because foliage balances atmospheric demand for water vapor with the supply from the soil-plant hydraulic system via g. Diffusion of CO_2 into foliage is a function of g, thus photosynthetic carbon assimilation (A) should also increase if soil water availability increases. Such an increase in g and A may be a proximal mechanism of increased growth after thinning. If this is the mechanism of growth response, it should be recorded in the $\delta^{13}C$ record of tree rings. Photosynthesis by terrestrial C_3 plants discriminates against CO_2 with ^{13}C relative to CO_2 with ^{12}C because ^{13}C has a lower diffusivity through the stomatal pore and lower reactivity with the photosynthetic enzymes. This discrimination results in a decrease in $\delta^{13}C$ of plant matter of approximately 20‰ below that of atmospheric CO_2. Discrimination can be expressed mathematically as:

(1)

$$\Delta = a + (b - a) \bullet \frac{C_i}{C_a}$$

where a and b are fractionation constants and C_i and C_a are the intercellular and atmospheric partial pressures of CO_2, respectively. Discrimination is physiologically linked to gas-exchange because g and A regulate C_i:

(2)

$$C_i = C_a - \frac{A}{g}$$

A/g is also referred to as the intrinsic water use efficiency. Changes in A/g cause a proportional change in Δ. This will result in a change in $\delta^{13}C$ because $\delta^{13}C$ is related to Δ as:

(3)

$$\Delta = \frac{\delta^{13}C_p - \delta^{13}C_a}{1 + \delta^{13}C_p / 1000}$$

where $\delta^{13}C_a$ and $\delta^{13}C_p$ are the isotope compositions of the source air used for photosynthesis and from tree-ring cellulose, respectively. Because cellulose is immobile within tree rings once it has been deposited within the cell walls, it can be analyzed to provide an isotopic record at the annual timestep. Therefore, tree-ring cellulose can be used as a record of crown-scale A/g.

A/g is negatively correlated with water availability because g increases more in response to increasing water availability than the concomitant increase in A. However, in thinned forests this response may be mediated or even overwhelmed by a simultaneous increase in nutrient or light availability associated with disturbance. Alternatively, there may be no response of A/g to thinning, potentially due to a balancing effect of increased light or nitrogen (which should increase A/g) against the effect of increased soil moisture (which should decrease A/g).

The primary objectives of our study were to 1) determine if growth responds to thinning in large, old ponderosa pine trees, 2) determine if canopy gas exchange responds to thinning, and 3) if responses are observed, to determine the duration of such responses if *LAI* remained below pre-thinning levels. Through this analysis we were able to examine many theoretical concepts dealing with the relationships between growth and canopy-scale physiology that have not previously been examined. To accomplish this, we developed a unique model to predict photosynthesis and conductance (see McDowell et al. 2003 for details).

Results

Figure 1. A stand of Pinus ponderosa prior to thinning. Notice the high density of trees.

Figure 2. A stand of Pinus ponderosa after thinning. Notice the low density of trees.

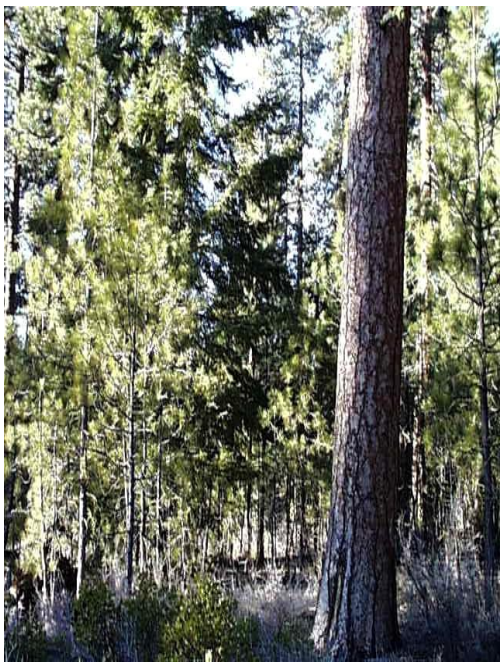


Figure 3. A core extracted from the side of an old-growth Pinus ponderosa tree. The thinning occurred ~15 years prior to extraction of the core. The outer edge of the core is on the right hand side and represents the most recent growth, with the left hand side of the core representing annual rings from earlier in the life of the tree.

Figure 4. This figure shows the large growth (BAI) response of trees to stand density reductions, and as well, the large D response. A) BAI and B) D of trees from the paired thinned and control portions of a single stand. Trees from the thinned stand are indicated by closed symbols and from the control stand are indicated by open symbols. The date of thinning is indicated by the dashed line. Values are means with standard errors. Similar results were found in two other stands (results not shown).

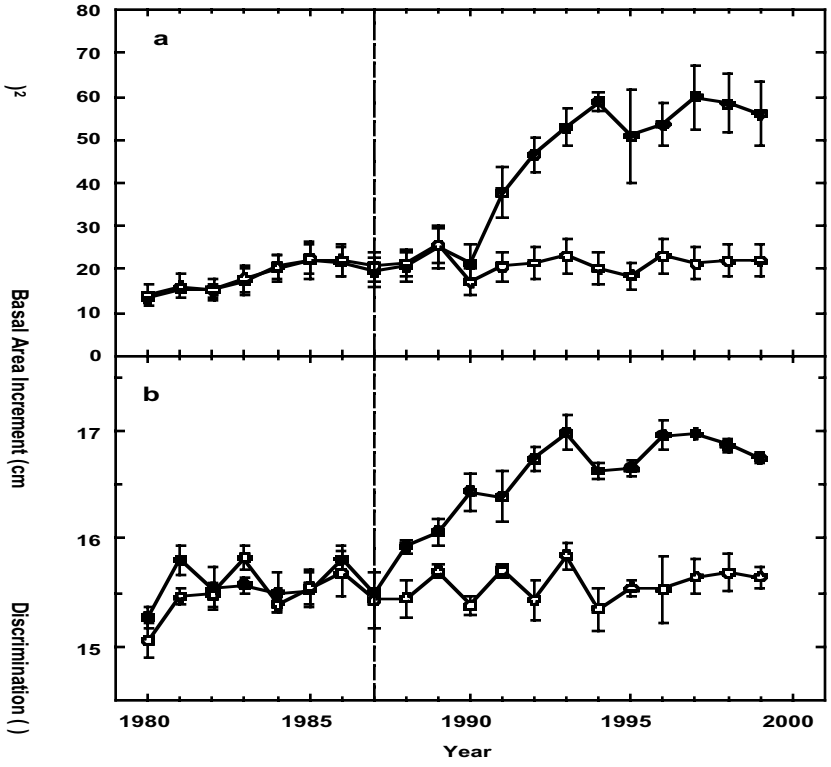


Figure 5. This figure demonstrates a strong relationship between soil water availability and D. Mean D vs. mean ψ pre-dawn for trees in the thinned and controls stands at three different sites. ψ pre-dawn is a direct measure of soil water availability. Control stands are indicated by open symbols and thinned stands are indicated by closed symbols. Bars are standard errors.

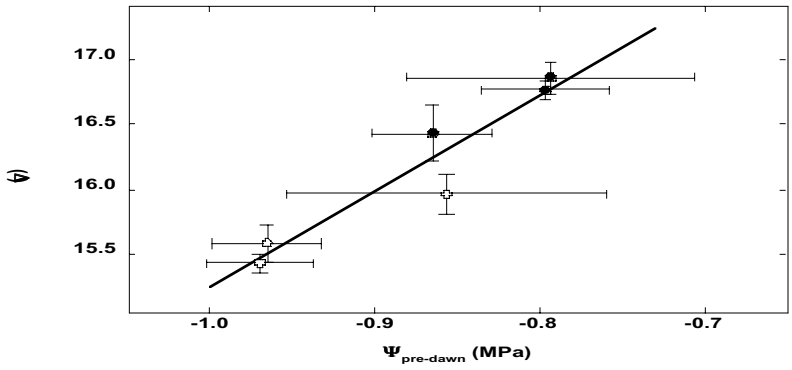


Figure 6. Model results, parameterized with the D data, demonstrate the substantial changes in A and g after stand density reductions. A) Modeled A and B) modeled g for the trees from the control stands (open symbols) and thinned stands (closed symbols). C) The percent change in A (open symbols) and g (closed symbols) for trees in the thinned plot at Site A. The date of thinning is indicated by the dashed line. Bars are standard errors.

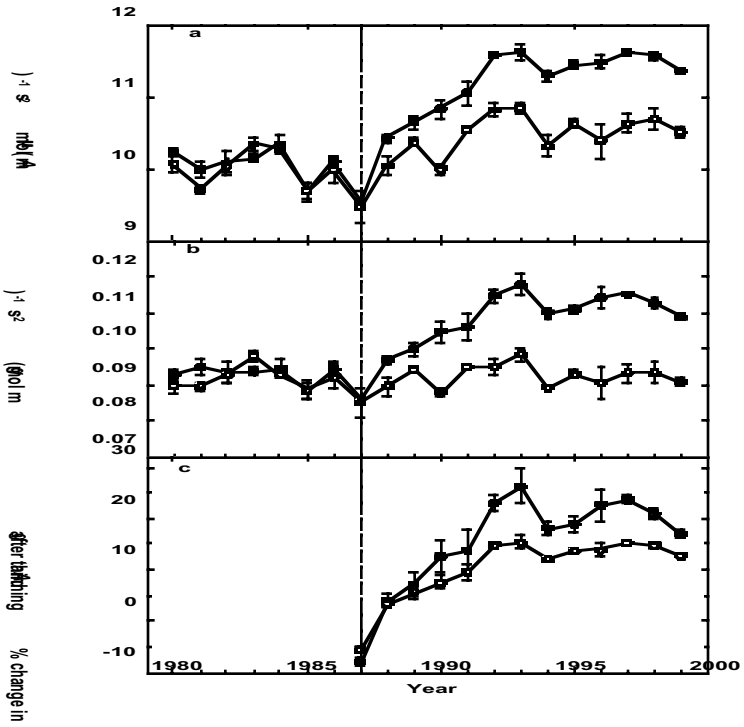


Figure 7. This figure demonstrates that the large change in growth (BAI) occurs a few years after the response of carbon assimilation (A, from the model). BAI (open symbols) and A (filled symbols) are from the control and thinned trees at a single stand. The stand was thinned in 1987. Bars are standard errors.

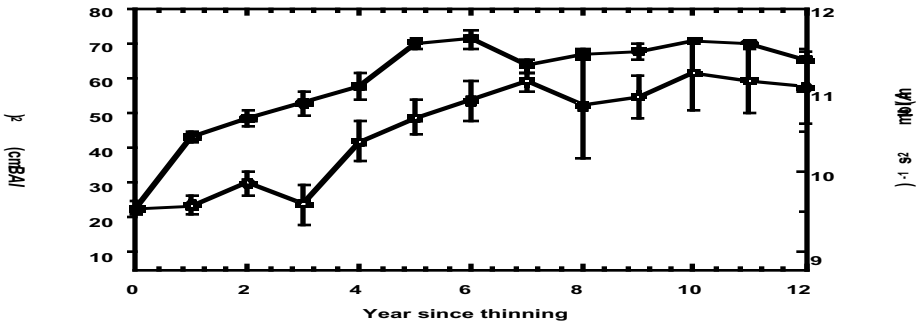
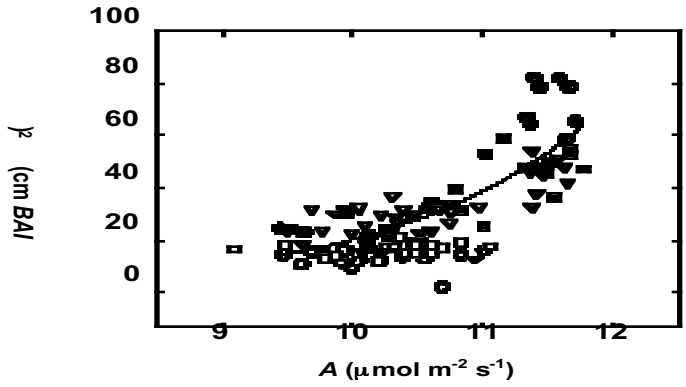


Figure 8. This figure plots the same data as from Figure (4) but with BAI vs. A for control trees (open symbols) and thinned trees (closed symbols). This figure demonstrates that stemwood growth is related to carbon assimilation, but not in the linear fashion that is expected when carbon allocation to stemwood growth is a constant fraction of carbon assimilation. This results from the lag shown in Figure (4), and suggests that another sink for carbon (e.g. roots, canopy) receives the "extra" carbon in the years immediately following thinning.



Discussion and Conclusion

There are important implications of these results. First, the observation that soil water availability, canopy gas exchange, and subsequent growth remain elevated as long as competition remains low means that forest managers can effectively manipulate old-growth stands on an infrequent basis. The advantages to old-growth ecosystems are that susceptibility to fires, insects, and drought can be mitigated, and tree-level productivity can be enhanced with minimal mechanical damage associated with the harvest. Second, the strong growth and Δ response to stand density reductions re-affirms the caution that dendrochronologists and dendroclimatologists have used in selecting trees that have not experienced substantial disturbance. Stand density reductions cause patterns in tree rings that appear similar to periods of wetter than normal climate, i.e. both cause increased Δ and growth. Therefore, site disturbances such as windthrow, fire, floods, insect induced mortality, and in recent centuries, harvest, may be misinterpreted in the tree-ring chronology as representative of cool, wet periods. Lastly, the variable lag between Δ and growth suggests that shifts in carbon allocation co-occur with changes in gas exchange after increases in soil water availability. Future work should quantify the interaction between resource availability, carbon assimilation, and carbon allocation.

REFERENCES

McDowell, N.G., J.R. Brooks, S.A. Fitzgerald, and B.J. Bond. 2003. Carbon isotope discrimination and growth response of old Pinus ponderosa trees to stand density reductions. Plant, Cell and Environ. 26:631-644.

Read More: Reader of the Rings
September 2003
http://ees.lanl.gov/archive_index/index.shtml

News, Views & EEScience:

A Monthly Newsletter from
Terry C. Wallace, Jr.
EES Acting Division Leader
wallacet@lanl.gov

tcw@losalamos.com
(In Confidence)
7-3644
Mail Stop D446

Additional information regarding this publication, please contact:

Dottie Austin, EES-DO, Editor/
Project Leader
dot@lanl.gov
7-3175
Mail Stop D446